

# IMPLOSION PROOF STRUCTURE IN FLAT CATHODE RAY TUBE

## BACKGROUND OF THE INVENTION

### Field of the Invention

5           The present invention relates to a flat cathode ray tube, and more particularly, to an implosion proof structure in a flat cathode ray tube for preventing implosion of the flat cathode ray tube.

### Background of the Related Art

10           Referring to FIG. 1, a related art flat cathode ray tube is provided with a planar panel 1, a funnel 3 smoothly curved from a sealing surface to the panel to a neck portion 3a having an electron gun sealed therein, welded to the panel 1 with Frit glass, and an electron gun 4 sealed in the neck portion for emitting red, green and blue electron beams toward the panel. In detail, there is a piece 2 of explosion proof glass attached to a front face of the panel for enhancing an explosion proof property of the panel 1, and a fluorescent film 5 on an inside surface of the panel for emitting a light as the electron beams hit the fluorescent film 5. And, there is a rectangular rail 6 on an inside surface of the panel, and a shadow mask 7 fitted to the rail 6 in an effective surface of the panel 1 having a lot of slits for selecting a color from the electron beams. And, there is an inner shield 8 fixed in rear of the rail for protecting the electron beams emitted from the electron gun and travelling toward the panel from geomagnetism, and a deflection yoke 9 on an outer circumferential surface of the neck portion of the funnel for deflecting the electron beams in a horizontal and a vertical directions. And, there is a band 11 strapped around the panel 1 for

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fastening a plurality of lugs 10 to an outer circumference of the panel 1, for use in fastening the foregoing flat cathode ray tube to a sash of a monitor or a TV receiver.

Accordingly, when a power is provided to the electron gun 4 sealed in the neck portion 3a, to emit thermal electrons, the emitted electrons are accelerated and focused as the thermal electrons pass through a plurality of electrodes in succession, and directed toward a screen side under a state deflected in a vertical and a horizontal direction by the deflection yoke 9. The electron beams emitted from the electron gun 4 and directed toward the screen side are involved in color selection as the electron beams pass through fine holes in the shadow mask 7, and hit onto fluorescent material in the fluorescent film 5. Eventually, a picture is reproduced as the fluorescent material emits lights owing to an energy difference occurred when electrons in the fluorescent material is once excited and dropped down to a base state. In order to enhance the electron emission, the cathode ray tube is passed through an evacuation process in fabrication of the cathode ray tube for keeping an inside of the cathode ray tube to be under a vacuum in a  $10^{-6} \sim 10^{-7}$  Torr range.

The evacuation process for the related art flat cathode ray tube will be explained, briefly.

Once the cathode ray tube having the funnel 3 fitted to the flat panel 1 is subjected to the evacuation process, down to a vacuum of in a range of  $10^{-7} \sim 10^{-8}$  Torr, there is a pressure difference between an inside and outside of the cathode ray tube of at least  $10^{-6}$  Torr since outside of the cathode ray tube is at a 760Torr atmospheric pressure. That is, the cathode ray tube is under one atmospheric pressure, i.e.,  $1.01325 \times 10^5$  N/m<sup>2</sup> pressure on all over thereof. Consequently, the panel and the funnel are deformed by the pressure until the outer and inner pressures come to a balance, particularly, the panel 1 collapses inward of the cathode ray tube in a "c" direction in FIG. 2. Moreover, as a provision for fixing the cathode ray tube passed through

the evacuation process to the sash of the monitor or the TV receiver, if the band assembly of the lugs 10 and the band 1 is strapped around the panel 1 under a tension, the inward collapse of the panel becomes more serious. That is, as shown in FIG. 2, in the related art implosion proof structure in the cathode ray tube, the strapping of the band 11 around the panel 1 with a tension, having an inward deformation along an axis of the tube of a bulb(the panel plus the funnel) already from the evacuation process, makes the deformation more serious. Because a stress is greater in the vicinity of a sealed surface of the panel 1 and the funnel 3, a breakage of the cathode ray tube may happen in the vicinity of the sealed surface by permanent stresses coming from the one atmospheric pressure difference caused by the evacuation and the strapping force caused by the band around the panel 1. Accordingly, the panel is susceptible to an implosion, in which the cathode ray tube implode even by a small external impact, and liable to have a poor picture quality since a front face of the panel is not flat.

For preventing such an implosion of the panel, as an example, the panel in the related art flat cathode ray tube has a thickness at a central portion thereof set greater than the same of cathode ray tube with a conventional radius of curvature. However, the thicker panel causes the following problem.

In the evacuation process of the cathode ray tube in fabrication of the cathode ray tube, the bulb is heated to a temperature in a range of approx.  $340 \sim 360^{\circ}\text{C}$  for extracting gas adsorbed in an inside surface of the bulb. A heat generated at a heater in a furnace heats an outer surface of the bulb by means of convection, and the heat at the outer surface of the bulb is transferred to the inside surface of the bulb by conduction. While glass has a thermal conductivity in a range of approx.  $0.92 \times 10^{-3} (\text{W}/\text{mm}^{\circ}\text{K})$ , the rail, a metal, has a thermal conductivity in a range of approx.  $22.8 \times 10^{-3} (\text{W}/\text{mm}^{\circ}\text{K})$ , i.e., the thermal conductivity of glass is relatively lower than the

metal. As a heat conduction is inversely proportional to a thickness of the panel, the bulb may be broken by a thermal stress coming from a temperature difference between an inner surface and an outer surface of the bulb which becomes the greater as the thickness of the flat panel 1 the greater. On the other hand, in a Frit sealing process in which the panel 1 and the funnel 3 are sealed with Frit glass carried out before the evacuation, when the Frit glass is crystallized to seal the panel 1 and the funnel 2, the bulb is required to be heated up to approx. 440°C according to a crystallization characteristic of the Frit glass. Therefore, when the thickness of the panel 1 is thick, the bulb may be broken by a temperature difference between the inner surface and the outer surface of the bulb. In order to minimize such a breakage, the heating process is required to be prolonged for heating the bulb slowly in an intention to reduce the temperature difference between the inner surface and the outer surface of the bulb, which deteriorates a yield, requires much time period for fabrication, and much heat energy. And, in a case the panel 1 has a thickness equal to, or greater than 18.0mm, a tint glass application with a light transmittivity of 75% at a thickness of 10.16mm shows a light transmittivity below 40%, and a dark tint glass application with a light transmittivity of 46% at a thickness of 10.16mm shows a light transmittivity below 28%, which is impossible to apply actually. Accordingly, there may be a limitation imposed on the design of the bulb that only a clear glass application with a light transmittivity of 86% at a thickness of 10.16mm and a semi-clear glass application with a light transmittivity of 82% at a thickness of 10.16mm are possible. Because the bulb is liable to break when an external impact is applied if the permanent stress caused by the vacuum is excessive, an allowable vacuum stress is restricted to be below 85 ~ 120kgf/cm<sup>2</sup>.

Furthermore, as another example of the related art implosion proof structure, since the flat cathode ray tube has a low implosion proof strength, an implosion proof glass is attached to a

front face of the panel by using a resin for absorbing an external impact to the cathode ray tube. However, since a lamination process for attaching the implosion proof glass is required to be carried out in a separate clean room where a cleanness is maintained enough to prevent occurrence of foreign matter or blow holes, fabrication process becomes complicate, to push up  
5 a production cost. And, the blow holes occurred in the lamination process increases defect of the cathode ray tube, with a poor productivity.

### SUMMARY OF THE INVENTION

Accordingly, the present invention is directed to an implosion proof structure in a flat cathode ray tube that substantially obviates one or more of the problems due to limitations and disadvantages of the related art.  
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An object of the present invention is to provide an implosion proof structure in a flat cathode ray tube, which can moderate a stress in the panel for enhancing an implosion proof strength of the cathode ray tube and preventing implosion of the cathode ray tube.

Additional features and advantages of the invention will be set forth in the description which follows, and in part will be apparent from the description, or may be learned by practice  
15 of the invention. The objectives and other advantages of the invention will be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these and other advantages and in accordance with the purpose of the present  
20 invention, as embodied and broadly described, the implosion proof structure in a flat cathode ray tube having a panel the atmospheric pressure exerts thereto as the flat cathode ray tube is evacuated includes implosion proof means strapped or coated on an outer circumferential surface of a funnel in the vicinity of the panel.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

### BRIEF DESCRIPTION OF THE DRAWINGS

5 The accompanying drawings, which are included to provide a further understanding of the invention and are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and together with the description serve to explain the principles of the invention:

In the drawings:

FIG. 1 illustrates a longitudinal section of a related art flat cathode ray tube;

10 FIG. 2 illustrates deformation of a panel in a related art flat cathode ray tube when evacuated, schematically;

FIG. 3 illustrates a side view with a partial cut away view of a flat cathode ray tube in accordance with a first preferred embodiment of the present invention;

15 FIG. 4 illustrates deformation of a panel in a flat cathode ray tube in accordance with a first preferred embodiment of the present invention when evacuated, schematically;

FIG. 5 illustrates a side view with a partial cut away view of a flat cathode ray tube in accordance with a second preferred embodiment of the present invention; and,

FIG. 6 illustrates a partial side sectional view of a flat cathode ray tube in accordance with a third preferred embodiment of the present invention, schematically.

### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

20 Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. FIG. 3 illustrates a side view with a partial cut away view of a flat cathode ray tube in accordance with a first

preferred embodiment of the present invention.

Referring to FIG. 3, the implosion proof structure in a flat cathode ray tube in accordance with a first preferred embodiment of the present invention includes a band 110 strapped around a flat portion of a funnel which is perpendicular to the panel for fastening lugs 100 thereto, to fasten the cathode ray tube to a sash of a monitor or TV receiver. In this instance, the band 110 is required to be strapped with a tension in a range of 600kgf ~ 3000kgf. If the tension is below 600kgf, an amount of restoration from a deformation caused by the evacuation to an original form by the tension of the band is less than 10%, which is not a substantial improvement of the cathode ray tube deformation. Opposite to this, since the improvement of the cathode ray tube deformation brought about when the tension is greater than 3000kgf is almost the same with the same when the tension is below 3000kgf, no substantial improvement of the deformation is expected. That is, if the tension of the band 110 is below 600kgf, an effect of the improvement is not enough as the improvement is below 10%, while the tension greater than 3000kgf provides no much improvement of the deformation in comparison to a case of tension below 3000kgf. An outer circumferential surface of the funnel 30 the band 110 is fastened thereto is a flat portion 120 perpendicular to the panel 10 larger than a width of the band 110, for preventing the band 110 from slipping away from a proper position, but to make a stable strapping.

It is preferable that the width of the flat portion 120 of the funnel 30 the band 11 is strapped thereto is larger than 16mm on the following reasons.

Alike the case of related art, if the panel 10 and the funnel 30, sealed together, are subjected to the evacuation process, a contraction is occurred, in which a central portion of the panel 10 collapses toward an inside of the cathode ray tube. As shown in FIG. 4, when the band 110 is strapped on the flat portion 12, an outer circumferential surface of the funnel 30, in the

vicinity of the panel 10 under a proper tension, a strapping tension of the band exerts in a direction shown as "a". According to this, a rim of the panel displaces in a direction shown as "b", and the central portion of the panel displaces in a direction shown as "c". Those displacements restore the displacement of the panel 10 caused by the evacuation close to an original state. The width of the band 110 versus the strapping tension can be expressed by an equation (1), below.

$$W = T / (t \times \sigma) \text{----- (1),}$$

where, 'W' denotes a width of the band, 't' denotes a thickness of the band, 'T' denotes the strapping tension, and 'σ' denotes a yielding strength of the band. In general, a material used as the band in the cathode ray tube has the yielding strength of approx. 32kgf/cm<sup>2</sup>, and 't' in a range of 1.2mm. Therefore, according to the equation (1), it can be known that the width of the band 110 is required to be at least 16mm for having the strapping tension to the band to be greater than 600kgf. According to this, it can also be known that a width of the flat portion 120 of the outer circumferential surface of the funnel formed perpendicular to the panel 10 is required to be at least 16mm for a stable fastening of the band 110 around the outer circumferential surface of the funnel

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FIG. 5 illustrates a side view with a partial cut away view of a flat cathode ray tube in accordance with a second preferred embodiment of the present invention, wherein the band 110 in the first embodiment is replaced with a wire 13 in the second embodiment. Since a strapping tension of the wire 130 is also required to be in a range of 600kgf ~ 3000kgf in strapping the wire 130, conditions for the wire 130 can be derived from the equation (1), as follows.

$$W = T / (t \times \sigma) \text{----- (1),}$$

where, 'T' denotes the strapping tension, and 'σ' denotes a yielding strength of the wire 130, and a sectional area of the band W×t may be substituted with π×R<sup>2</sup>, to express the radius 'R' of the



wire as an equation (2) below.

$$R = \sqrt{T / (\pi \times \sigma)} \text{-----} (2),$$

where, T denotes the strapping tension,  $\sigma$  denotes a yielding strength of the wire 13, and R is a radius of the wire 130. For example, if a wire 130 of a chrome steel with a yield strength 41.8kgf/mm<sup>2</sup> is used, a required radius of the wire 130 is 2.5mm or greater from the equation (2), when the strapping tension is greater than 600kgf.

A deformation behaviour of the flat cathode ray tube with the aforementioned implosion proof structure in accordance with a second preferred embodiment of the present invention will be explained.

In the evacuation process after the funnel is welded to the panel, and the electron gun is sealed in the funnel, as shown in FIG. 2, the cathode ray tube is involved in collapse of the central portion of the panel toward an inside of the cathode ray tube, and the rim extended outward. In this instance, when the band and the wire 130 have the same sectional areas, the wire 130 has a contact area smaller than the band, to require a smaller width of the flat portion than the band.

As shown in FIG. 4, when the band or wire 130 is strapped around the outer circumferential surface 120 of the funnel in the vicinity of a welded region of the panel and the funnel of the foregoing flat cathode ray tube with a tension, the strapping tension is applied in an "a" direction, so that the rim of the panel displaces in the a "b" direction, and the central portion of the panel displaces in a "c" direction, offsetting the deformation caused by the evacuation, and restoring the cathode ray tube to a form close to a form before the evacuation. Since the offsetting of the deformation reduces the permanent stress in the flat cathode ray tube, the flat cathode ray tube is made to have an anti-implosion strength which can endure against an external impact, well.

FIG. 6 illustrates a partial side sectional view of a flat cathode ray tube in accordance with a third preferred embodiment of the present invention schematically, wherein a hardening adhesive 140 is applied to an outer circumferential surface of a front portion of the funnel in the vicinity of a welded region of the panel 10 and the funnel 30. The hardening adhesive 140 is of a material hardened by oxygen, heat, or water to have a certain tensile strength, such as a ceramic adhesive. In the evacuation, the deformation and a consequential tensile stress are occurred at the welded region of the panel and the funnel mostly, i.e., a force ② applied to the funnel from the atmospheric pressure causes a maximum vacuum stress at the welded region in a short axis direction of the panel and the funnel, which in turn causes a deformation of the cathode ray tube as shown in dashed lines in FIG. 6. However, the hardening adhesive 14 coated on the outer circumferential surface of the funnel forms a force ① opposing the force ② from the atmospheric pressure which exerts in a direction the panel collapses toward the inside of the cathode ray tube, and makes a balance against the force ② from the atmospheric pressure, leading the flat cathode ray tube restored to a form before the evacuation as shown in solid line in FIG. 6, which may be described in detail as follows.

The force from the hardening adhesive 14 to the panel of the cathode ray tube can be defined similar to the equation (1) as shown below.

$$W = Ta / (t \times \sigma) \text{----- (1),}$$

where, Ta denotes the force applied to the cathode ray tube from the atmospheric pressure, and, since it is required to apply a strapping tension at least equal to the Ta, the hardening adhesive is required to have a yield strength 'σ', a thickness 't' and a width 'W'. And, the strapping force from the hardening adhesive 140 to the outer circumferential surface of the funnel can be expressed as an equation (3), below.

$$T = p \times R \times W \text{ ----- (3),}$$

where, 'T' denotes the strapping force from the hardening adhesive 140 to the funnel, 'p' denotes a pressure from a unit area of the hardening adhesive, and R denotes an outer circumference of the funnel, and 'W' denotes a width of the hardening adhesive. Because the force from the hardening adhesive 140 to the outer circumference of the funnel 3 is required to be equal to, or greater than the force from the atmospheric pressure to the panel, for prevention of the deformation of the panel, a relation of the equations (1) and (2) can be expressed as inequalities shown below.

$$T \geq Ta, \text{ and } p \times R \geq \sigma \times t \text{ -----}$$

(4).

That is, since the force Ta from the atmospheric pressure to the cathode ray tube is constant, after the yield strength of the hardening adhesive is fixed, the thickness 't' and the width 'W' are fixed according to equations (1) and (4), i.e.,  $t \geq Ta/(\sigma \times W)$ , and  $W \geq Ta/(p \times R)$ . And, in order to make the hardening adhesive to compress the flat cathode ray tube effectively, it is required to set a difference of thermal expansion/contraction coefficients between the hardening adhesive after hardened and the funnel to be approx.  $5 \times 10^{-7}/^{\circ}\text{C}$ , for maintaining constant compression as the hardening adhesive and the funnel 140 expand/contract in similar ratios when a heat is generated by the electron beams at operation of the flat cathode ray tube. If the hardening adhesive 140 has a small thermal expansion coefficient, the hardening adhesive 140 expands less than the funnel when the flat cathode ray tube is in operation, compressing the funnel excessively, that bulges the panel forward. And, if the hardening adhesive 140 has a great thermal expansion coefficient, the hardening adhesive 140 expands larger than the funnel, failing to compress the funnel effectively, the collapse of the panel is occurred.

As an example of such a coating of hardening adhesive, the width and the thickness of a ceramic adhesive coated on a 17" cathode ray tube will be calculated. In this instance, as the atmospheric pressure is 0.01034kg/mm<sup>2</sup> and the 17" flat cathode ray tube has a panel area of 97900mm<sup>2</sup>, the force T from the atmospheric pressure to the front face of the panel is 1012kgf.

And, as the ceramic adhesive has a yield strength of 25kg/mm<sup>2</sup>, and a length of the outer circumference of the funnel of approx. 1260mm, the thickness 't' of the hardening adhesive is set to be 0.5mm since  $t \geq Ta/(\sigma \times W)$  according to the equation (1). Then, a pressure per a unit area of the funnel from the ceramic adhesive is 0.0099kg/mm<sup>2</sup> according to the equation (4). And, as the width 'W' of the ceramic adhesive is  $W \geq Ta/(p \times R)$ , the width 'W' is greater than 81mm.

Thus, since the displacements occurred in the evacuation of the flat cathode ray tube is restored by a strapping force of the band, wire, or the hardening adhesive on around the funnel, a thickness of the panel can be reduced substantially as the implosion proof strength of the panel is enhanced, that in turn facilitates to reduce a temperature difference between the inner and the outer circumferential surface of the panel 100 in the Frit sealing, and evacuation processes when the panel 10 and the funnel 30 are welded. That is, tint glass with a reflectivity of 0.045 and a light absorptivity of 0.04626 or clear glass with a reflectivity of 0.045, the same with the tint glass, and a light absorptivity of 0.00578, are used. If the panel is formed of tint glass, the panel has a thickness of 18.0mm and a light transmittivity of 40% or below. Eventually, since the present invention permits to reduce the panel thickness, the limitation on the design of the flat cathode ray tube is reduced as, not only the clear glass, but also tint glass, can be used. And, as the panel has a sufficient implosion proof strength, no implosion proof glass is required. In this instance, it is apparent to a person skilled in this field of art that there may be a variety of

applications, such as the band is not necessarily used for fastening the lugs, but, in a state a band for fastening the lugs are strapped around the panel, another band may be strapped around the funnel.

As has been explained, the implosion proof structure in a flat cathode ray tube of the present invention can restore a cathode ray tube to an original form, for preventing an implosion of the cathode ray tube, by strapping or coating a band, wire, or hardening adhesive around the funnel to moderate a permanent stress occurred in the cathode ray tube owing to a pressure difference between an inside and outside of the cathode ray tube. The enhancement of the implosion proof strength of the cathode ray tube caused by the strapping or coating eases a limitation of the panel design as even a thin panel can meet an allowable vacuum stress. And, since no implosion proof glass is required on the front face of the panel, a fabrication process is simplified, a productivity is improved, and a production cost is reduced.

It will be apparent to those skilled in the art that various modifications and variations can be made in the implosion proof structure in a flat cathode ray tube of the present invention without departing from the spirit or scope of the invention. Thus, it is intended that the present invention cover the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.